

Exhibit J

Digital Imaging and Communications in Medicine (DICOM)

Supplement 61: JPEG 2000 Transfer Syntaxes

DICOM Standards Committee, Working Group 4 Compression

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Foreword

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60 This Supplement has been prepared by the DICOM Working Group 4 (Compression) according to
61 the procedures of the DICOM Committee.

62 The DICOM Standard is structured as a multi-part document using the guidelines established in the
63 following document:

64 - ISO/IEC Directives, 1989 Part 3: Drafting and Presentation of International Standards.

65 This document is a Supplement to the DICOM Standard. It is an extension to PS 3.3, 3.4 and 3.6 of
66 the published DICOM Standard, which consists of the following parts:

- | | | |
|----|---------|---|
| 67 | PS 3.1 | - Introduction and Overview |
| 68 | PS 3.2 | - Conformance |
| 69 | PS 3.3 | - Information Object Definitions |
| 70 | PS 3.4 | - Service Class Specifications |
| 71 | PS 3.5 | - Data Structures and Encoding |
| 72 | PS 3.6 | - Data Dictionary |
| 73 | PS 3.7 | - Message Exchange |
| 74 | PS 3.8 | - Network Communication Support for Message Exchange |
| 75 | PS 3.9 | - Point-to-Point Communication Support for Message Exchange |
| 76 | PS 3.10 | - Media Storage and File Format for Data Interchange |
| 77 | PS 3.11 | - Media Storage Application Profiles |
| 78 | PS 3.12 | - Media Formats and Physical Media for Data Interchange |
| 79 | PS 3.13 | - Print Management Point-to-Point Communication Support |
| 80 | PS 3.14 | - Grayscale Standard Display Function |
| 81 | PS 3.15 | - Security Profiles |
| 82 | PS 3.16 | - Content Mapping Resource |

83 These parts are related but independent documents.

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Scope and Field of Application

INTRODUCTION.

Additional DICOM Transfer Syntaxes are introduced to add support for the JPEG 2000 Part 1 ~~lossy~~ lossless and lossy compression schemes.

When first introduced, DICOM contained support for the lossless and lossy compression processes defined in the “original” JPEG standard, ISO 10918-1. Though that standard supported various different processes, in practice only those based on sequential block-based DCT Huffman entropy coding for lossy compression and predictive coding with Huffman entropy coding for lossless compression have been widely used.

Given that there are both real and perceived limitations with 10918-1 JPEG, WG 4 began to investigate alternatives, particularly those based on wavelet transformation, multi-resolution analysis and more sophisticated entropy coders than Huffman coding.

Working Group 4 set aside its effort to develop its own (medically specific) image data compression standard when the call for proposals for “JPEG 2000” was announced by ISO/IEC JTC1/SC29/WG1. Since then, efforts have been directed towards developing JPEG 2000 (ISO 15444-1), and ensuring that it provides features which are needed for medical imaging.

The use of ISO/IEC 15444-1 does not necessarily result in improved compression performance for any particular application (in terms of quantitative or qualitative measures of image fidelity, preservation of diagnostically significant information, consumption of resources such as memory or compression and decompression speed). However, JPEG 2000 offers additional features that may be important for some medical applications in which DICOM is used. These features include progressive and embedded spatial and contrast resolution, progression to lossless reconstruction, regions of interest and so on.

At the present time, only the features included in Part 1 of JPEG 2000 (ISO/IEC 15444-1) are included in this proposal. All JPEG 2000 implementations are required to support all features of Part 1 and accordingly this is expected to be a “baseline” for all available codecs. Other proposed parts of JPEG 2000 included additional features that may be of interest for medical imaging, such as alternative quantization methods (such as TCQ) and wavelet transforms in more than two dimensions (potentially useful for hyper-spectral and 3D volume data compression). If these “extensions” to JPEG 2000 prove viable and receive widespread support by codec implementers then they could be added as additional separate Transfer Syntaxes in DICOM.

The introduction of the JPEG 2000 transfer syntaxes is in no way intended to imply that the compression schemes already incorporated in the standard, some of which are widely used, are in some way “inferior”. Likewise, the introduction of JPEG 2000 does not imply endorsement of the scheme for any particular clinical or diagnostic application. The standard simply makes the scheme available; it is the responsibility of individual users, vendors, regulatory agencies and professional societies to ascertain the safety and efficacy of the use of any tool for a particular clinical application.

At the same time as introducing new Transfer Syntaxes, the opportunity is taken to retire those existing Transfer Syntaxes that are not in use. Also, the unused and deprecated ARGB Photometric Interpretation is also retired.

DESIGN DECISIONS

The approach proposed is to encapsulate JPEG 2000 bit streams in exactly the same manner as is currently used for JPEG (10918-1), JPEG-LS and RLE. This implies that:

- Undefined length pixel data contains one or more sequence-item-like fragments preceded by a possibly empty offset table.

- Each frame (or an entire single frame image) will be in one or more fragments.
- The optional JP2 file format header defined in 15444-1 is not included, only the actual compressed JPEG bit stream (this is the same as for JPEG which does not include a JFIF header in the DICOM encapsulation and JPEG-LS which does not include a SPIFF header).
- Information that is not specified in the JPEG 2000 bit stream, such as what color component corresponds to each compressed component, is specified in the DICOM attributes, such as Photometric Interpretation (again, just like JPEG, JPEG-LS and RLE).
- Separate transfer syntaxes are defined for reversible and irreversible processes, in order to be able to negotiate reversible transfers.

FORM OF THIS SUPPLEMENT

This supplement adds new Transfer Syntaxes to support JPEG 2000, adds new Photometric Interpretations compatible with those used in JPEG 2000 encoded bit streams, and retires unused JPEG Transfer Syntaxes.

Since this document proposes changes to existing Parts of DICOM, the reader should have a working understanding of the Standard. This proposed Supplement includes a number of Addenda to existing Parts of DICOM:

- PS 3.3 Addendum: Information Object Definitions
- PS 3.5 Addendum: Data Structures and Encoding
- PS 3.6 Addendum: Data Dictionary
- PS 3.11 Addendum: Media Application Profiles

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Changes to

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NEMA Standards Publication PS 3.3-2000

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Part 3: Information Object Definitions

Add JPEG 2000 Photometric Interpretations to Image Pixel Module C.7.6.3:

C.7.6.3 Image Pixel Module

Table C.7-9 specified the Attributes that describe the pixel data of the image.

...

C.7.6.3.1 Image Pixel Attribute Descriptions**C.7.6.3.1.1 Samples Per Pixel**

Samples per Pixel (0028,0002) is the number of separate planes in this image. One, three, and four image planes are defined. Other numbers of image planes are allowed, but their meaning is not defined by this Standard.

For monochrome (gray scale) and palette color images, the number of planes is 1. For RGB and other three vector color models, the value of this attribute is 3. For ARGB and other four vector color models, the value of this attribute is 4.

All image planes shall have the same number of Rows (0028,0010), Columns (0028,0011), Bits Allocated (0028,0100), Bits Stored (0028,0101), High Bit (0028,0102), Pixel Representation (0028,0103), and Pixel Aspect Ratio (0028,0034).

The data in each pixel may be represented as a "Composite Pixel Code". If Samples Per Pixel is one, the Composite Pixel Code is just the "n" bit pixel sample, where "n" = Bits Allocated. If Samples Per Pixel is greater than one, Composite Pixel Code is a "k" bit concatenation of samples, where "k" = Bits Allocated multiplied by Samples Per Pixel, and with the sample representing the vector color designated first in the Photometric Interpretation name comprising the most significant bits of the Composite Pixel Code, followed in order by the samples representing the next vector colors, with the sample representing the vector color designated last in the Photometric Interpretation name comprising the least significant bits of the Composite Pixel Code. For example, for Photometric Interpretation = "RGB", the most significant "Bits Allocated" bits contain the Red sample, the next "Bits Allocated" bits contain the Green sample, and the least significant "Bits Allocated" bits contain the Blue sample.

C.7.6.3.1.2 Photometric Interpretation

The value of Photometric Interpretation (0028,0004) specifies the intended interpretation of the image pixel data.

See PS 3.5 for restrictions imposed by compressed Transfer Syntaxes.

The following values are defined. Other values are permitted but the meaning is not defined by this Standard.

MONOCHROME1 = Pixel data represent a single monochrome image plane. The minimum sample value is intended to be displayed as white after any VOI gray scale transformations have been performed. See PS 3.4. This value may be used only when Samples per Pixel (0028,0002) has a value of 1.

MONOCHROME2 = Pixel data represent a single monochrome image plane. The minimum sample value is intended to be displayed as black after any VOI gray scale transformations have been performed. See PS 3.4. This value may be used only when Samples per Pixel (0028,0002) has a value of 1.

PALETTE COLOR = Pixel data describe a color image with a single sample per pixel (single image plane). The pixel value is used as an index into each of the Red, Blue, and Green Palette Color Lookup Tables (0028,1101-1103&1201-1203). This value may be used only when Samples per Pixel (0028,0002) has a value of 1. When the Photometric Interpretation is Palette Color; Red, Blue, and Green Palette Color Lookup Tables shall be present.

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RGB = Pixel data represent a color image described by red, green, and blue image planes. The minimum sample value for each color plane represents minimum intensity of the color. This value may be used only when Samples per Pixel (0028,0002) has a value of 3.

HSV = Pixel data represent a color image described by hue, saturation, and value image planes. The minimum sample value for each HSV plane represents a minimum value of each vector. This value may be used only when Samples per Pixel (0028,0002) has a value of 3.

~~**ARGB** = Pixel data represent a color image described by red, green, blue, and alpha image planes. The minimum sample value for each RGB plane represents minimum intensity of the color. The alpha plane is passed through Palette Color Lookup Tables. If the alpha pixel value is greater than 0, the red, green, and blue lookup table values override the red, green, and blue pixel plane colors. This value may be used only when Samples per Pixel (0028,0002) has a value of 4. Retired.~~

CMYK = Pixel data represent a color image described by cyan, magenta, yellow, and black image planes. The minimum sample value for each CMYK plane represents a minimum intensity of the color. This value may be used only when Samples per Pixel (0028,0002) has a value of 4.

YBR_FULL = Pixel data represent a color image described by one luminance (Y) and two chrominance planes (C_B and C_R). This photometric interpretation may be used only when ~~S~~**S**amples per ~~P~~**P**ixel (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both C_B and C_R values equal to half full scale.

Note: In the case where the Bits Allocated (0028,0100) has value of 8 half full scale is 128.

In the case where Bits allocated (0028,0100) has a value of 8 then the following equations convert between RGB and $Y C_B C_R$ Photometric Interpretation.

$$Y = \quad + \quad .2990R + .5870G + .1140B$$

$$C_B = \quad - \quad .1687R - .3313G + .5000B + 128$$

$$C_R = \quad + \quad .5000R - .4187G - .0813B + 128$$

Note: The above is based on CCIR Recommendation 601-2 dated 1990

YBR_FULL_422 = The same as YBR_FULL except that the C_B and C_R values are sampled horizontally at half the Y rate and as a result there are half as many C_B and C_R values as Y values.

This ~~P~~**P**hotometric Interpretation is only allowed with Planar Configuration (0028,0006) equal to ~~0000~~**0000**. Two Y values shall be stored followed by one C_B and one C_R value. The C_B and C_R values shall be sampled at the location of the first of the two Y values. For each Row of Pixels, the first C_B and C_R samples shall be at the location of the first Y sample. The next C_B and C_R samples shall be at the location of the third Y sample etc.

Note: This subsampling is often referred to as cosited sampling.

YBR_PARTIAL_422 = The same as YBR_FULL_422 except that:

1. black corresponds to $Y = 16$;
2. Y is restricted to 220 levels (i.e. the maximum value is 235);
3. C_B and C_R each has a minimum value of 16;

4. C_B and C_R are restricted to 225 levels (i.e. the maximum value is 240);

5. lack of color is represented by C_B and C_R equal to 128.

In the case where Bits Allocated (0028,0100) has value of 8 then the following equations convert between RGB and YBR_PARTIAL_422 Photometric Interpretation

$$Y = \quad + \quad .2568R + .5041G + .0979B + 16$$

$$C_B = \quad - \quad .1482R - .2910G + .4392B + 128$$

$$C_R = \quad + \quad .4392R - .3678G - .0714B + 128$$

Note: The above is based on CCIR Recommendation 601-2 dated 1990.

YBR_ICT = Irreversible Color Transformation:

[Editor's note: not the same as YBR_FULL because of difference in level shifting ???]

Pixel data represent a color image described by one luminance (Y) and two chrominance planes (C_B and C_R). This photometric interpretation may be used only when $S_{\text{samples per Ppixel}}$ (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both C_B and C_R values equal to zero.

Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and YC_BC_R Photometric Interpretation.

$$Y = \quad + \quad .29900R + .58700G + .11400B$$

$$C_B = \quad - \quad .16875R - .33126G + .50000B$$

$$C_R = \quad + \quad .50000R - .41869G - .08131B$$

Notes: 1. The above is based on ISO/IEC 15444-1 (JPEG 2000).

2. In a JPEG 2000 bitstream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).

3. In JPEG 2000, spatial down-sampling of the chrominance components prior to compression is not performed, due to the multi-resolution decomposition approach of the compression scheme.

~~YUV-RCT~~YBR_RCT = Reversible Color Transformation:

Pixel data represent a color image described by one luminance (Y) and two chrominance planes (V and U). This photometric interpretation may be used only when $S_{\text{samples per Ppixel}}$ (0028,0002) has a value of 3. Black is represented by Y equal to zero. The absence of color is represented by both C_B and C_R . ~~V and U~~ values equal to zero. **[Editor's note: is this true ???]**

Regardless of the value of Bits Allocated (0028,0100), the following equations convert between RGB and ~~YUV-RCT~~YBR_RCT Photometric Interpretation.

$$Y = \lfloor R + 2G + B \rfloor / 4$$

$$C_B U = B - G$$

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$$C_{R^V} = R - G$$

The following equations convert between ~~YUV-RCTYBR~~ ~~RCT~~ and RGB Photometric Interpretation.

$$G = Y - [C_{R^V} + C_{B^U}] / 4$$

$$R = C_{R^V} + G$$

$$B = C_{B^U} + G$$

Notes: 1. The above is based on ISO/IEC 15444-1 (JPEG 2000).

2. In a JPEG 2000 bitstream, DC level shifting (used if the untransformed components are unsigned) is applied before forward color transformation, and the transformed components may be signed (unlike in JPEG ISO/IEC 10918-1).

3. This photometric interpretation is a reversible approximation to the YUV transformation used in PAL and SECAM.

C.7.6.3.1.3 Planar Configuration

Planar Configuration (0028,0006) indicates whether the color pixel data are sent color-by-plane or color-by-pixel. This Attribute shall be present if Samples per Pixel (0028,0002) has a value greater than 1. It shall not be present otherwise.

Enumerated Values:

~~000~~ = The sample values for the first pixel are followed by the sample values for the second pixel, etc. For RGB images, this means the order of the pixel values sent shall be R1, G1, B1, R2, G2, B2, ..., etc. For HSV images, this means the order of the pixel values sent shall be H1, S1, V1, H2, S2, V2, ... etc. For ARGB images, this means the order of the pixel values sent shall be A1, R1, G1, B1, A2, R2, G2, B2, ... etc. For CMYK images, this means the order of the pixel values sent shall be C1, M1, Y1, K1, C2, M2, Y2, K2, ... etc.

~~001~~ = Each color plane shall be sent contiguously. For RGB images, this means the order of the pixel values sent is R1, R2, R3, ..., G1, G2, G3, ..., B1, B2, B3, etc. For HSV images, this means the order of the pixel values sent is H1, H2, H3, ..., S1, S2, S3, ..., V1, V2, V3, etc. For ARGB images, this means the order of the pixel values sent is A1, A2, A3, ..., R1, R2, R3, ..., G1, G2, G3, ... B1, B2, B3... etc. For CMYK images, this means the order of the pixel values sent is C1, C2, C3, ..., M1, M2, M3, ..., Y1, Y2, Y3, ..., K1, K2, K3... etc.

Note: Planar Configuration (0028,0006) is not meaningful when a compression transfer syntax is used that involves reorganization of sample components in the compressed bit stream. In such cases, since the Attribute is required to be sent, then an appropriate value to use may be specified in the description of the Transfer Syntax in PS 3.5, though in all likelihood the value of the Attribute will be ignored by the receiving implementation.

Add JPEG 2000 Photometric Interpretations to US Image Module C.8.5.6:

C.8.5.6 US Image Module

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C.8.5.6.1.2 Photometric Interpretation

For US Images, Photometric Interpretation (0028,0004) is specified to use the following Defined Terms:

MONOCHROME2	PALETTE COLOR	RGB
ARGB (<i>retired</i>)	YBR_FULL	YBR_FULL_422
YBR_PARTIAL_422	YUV-RCT YBR_RCT	YBR ICT

Note: It is recommended that future implementations should not use ARGB photometric interpretation.

See PS 3.5 for restrictions imposed by compressed Transfer Syntaxes.

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C.8.5.6.1.12 Samples Per Pixel

For US Images, Samples Per Pixel (0028,0002) is specified to use the following values for specific Photometric Interpretations:

**Table C.8-19
US SAMPLES PER PIXEL**

Photometric Interpretation	Samples Per Pixel Value
MONOCHROME2	0001H
RGB	0003H
YBR_FULL	0003H
YBR_FULL_422	0003H
YBR_PARTIAL_422	0003H
YUV-RCT YBR_RCT	0003H
YBR ICT	0003H
PALETTE COLOR	0001H

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C.8.5.6.1.13 Bits Allocated

For US Images, Bits Allocated (0028,0100) is specified to use the following values for specific Photometric Interpretations:

Table C.8-20
US BITS ALLOCATED

Photometric Interpretation	Bits Allocated Value
MONOCHROME2	0008H
RGB	0008H
YBR_FULL	0008H
YBR_FULL_422	0008H
YBR_PARTIAL_422	0008H
YUV_RCT YBR_RCT	0008H
YBR ICT	0008H
PALETTE COLOR	0008H - 8 bit palette, or 0010H 16 - 16 bit palette

C.8.5.6.1.14 Bits Stored

For US Images, Bits Stored (0028,0101) is specified to use the following values for specific Photometric Interpretations:

Table C.8-21
US BITS STORED

Photometric Interpretation	Bits Stored Value
MONOCHROME2	0008H
RGB	0008H
YBR_FULL	0008H
YBR_FULL_422	0008H
YBR_PARTIAL_422	0008H
YUV_RCT YBR_RCT	0008H
YBR ICT	0008H
PALETTE COLOR	0008H - 8 bit palette, or 0010H 16 - 16 bit palette

C.8.5.6.1.15 High Bit

For US Images, High Bit (0028,0102) is specified to use the following values for specific Photometric Interpretations:

Table C.8-22
US HIGH BIT

Photometric Interpretation	High Bit Value
MONOCHROME2	0007H
RGB	0007H
YBR_FULL	0007H
YBR_FULL_422	0007H
YBR_PARTIAL_422	0007H
YUV_RCT YBR_RCT	0007H
YBR_ICT	0007H
PALETTE COLOR	0007H - 8 bit palette, or 000FH 15 - 16 bit palette

C.8.5.6.1.16 Planar Configuration

For US Images, Planar Configuration (0028,0006) is specified to use the following values for specific Photometric Interpretations:

Table C.8-23
US PLANAR CONFIGURATION

Photometric Interpretation	Planar Configuration Value
RGB	0000H - color-by-pixel, or 0001H - color-by-plane
YBR_FULL	0001H
YBR_FULL_422	0000H
YBR_PARTIAL_422	0000H
YUV_RCT YBR_RCT	0000H
YBR_ICT	0000H

Add JPEG 2000 Photometric Interpretations to VL Image Module C.8.12.1:

C.8.12.1 VL Image Module

...

C.8.12.1.1 VL Image Module Attribute Descriptions

C.8.12.1.1.1 Photometric Interpretation

The Enumerated Values of Photometric Interpretation (0028,0004) shall:

MONOCHROME2

RGB

YBR_FULL_422

~~YUV_RCT~~YBR_RCT

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375 YBR_ICT

376

377 **C.8.12.1.1.2 Bits Allocated, Bits Stored, and High Bit**

378 The Enumerated Value of Bits Allocated (0028,0100) shall be 8; the Enumerated Value of Bits
379 Stored (0028,0101) shall be 8; and the Enumerated Value of High Bit (0028,0102) shall be 7.

380 **C.8.12.1.1.3 Pixel Representation**

381 The Enumerated Value of Pixel Representation (0028,0103) shall be ~~0000H~~.

382 ~~Note: A value of 0000H signifies an unsigned integer value.~~

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384 **C.8.12.1.1.4 Samples per Pixel**

385 The Enumerated Values of Samples per Pixel (0028,0002) shall be as follows: If the value of
386 Photometric Interpretation (0028,0004) is MONOCHROME2, then the Enumerated Value of
387 Samples per Pixel (0028,0002) shall be one (1). If the value of Photometric Interpretation
388 (0028,0004) is RGB or YBR_FULL_422 or ~~YUV-RCT~~ **YBR_RCT** or **YBR_ICT**, then the Enumerated
389 Value of Samples per Pixel (0028,0002) shall be three (3).

390 **C.8.12.1.1.5 Planar Configuration**

391 If present, the Enumerated Value of Planar Configuration (0028,0006) shall be ~~0000H~~. This value
392 shall be present if Samples per Pixel (0028,0002) has a value greater than 1.

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Changes to

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Part 5: Data Structures and Encoding

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Add JPEG 2000 to Section 2:

Section 2 Normative references

The following standards contain provisions that, through references in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibilities of applying the most recent editions of the standards indicated below.

...

ISO/IS 10918-1 JPEG Standard for digital compression and encoding of continuous-tone still images. Part 1—Requirements and implementation guidelines

ISO/IS 10918-2 JPEG Standard for digital compression and encoding of continuous-tone still images. Part 2—Testing

ISO/IS 14495-1 Lossless and near-lossless coding of continuous tone still images (JPEG-LS)

ISO/IS 15444-1 JPEG 2000 Image Coding System

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Add JPEG 2000 to Section 8:

Section 8 Encoding of Pixel, Overlay and Waveform Data

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8.2 NATIVE OR ENCAPSULATED FORMAT ENCODING

Pixel data conveyed in the Pixel Data Element (7FE0,0010) may be sent either in a Native (uncompressed) Format or in an Encapsulated Format (e.g. compressed) defined outside the DICOM standard.

If Pixel Data is sent in a Native Format, the Value Representation OW is most often required. The Value Representation OB may also be used for Pixel Data in cases where Bits Allocated has a value less than or equal to 8, but only with Transfer Syntaxes where the Value Representation is explicitly conveyed (see Annex A).

Note: The DICOM default Transfer Syntax (Implicit VR Little Endian) does not explicitly convey Value Representation and therefore the VR of OB may not be used for Pixel Data when using the default Transfer Syntax.

Native format Pixel Cells are encoded as the direct concatenation of the bits of each Pixel Cell, where the most significant bit of a Pixel Cell is immediately followed by the least significant bit of the next Pixel Cell. The number of bits of each Pixel Cell is defined by the Bits Allocated (0028,0100) Data Element Value. When a Pixel Cell crosses a word boundary in the OW case, or a byte boundary in the OB case, it shall continue to be encoded, least significant bit to most significant bit, in the next word, or byte, respectively (see Annex D). For Pixel Data encoded with the Value Representation OW, the byte ordering of the resulting 2-byte words is defined by the Little Endian or Big Endian Transfer Syntaxes negotiated at the Association Establishment (see Annex A).

Notes: 1. For Pixel Data encoded with the Value Representation OB, the Pixel Data encoding is unaffected by Little Endian or Big Endian byte ordering.

2. If encoding Pixel Data with a Value for Bits Allocated (0028,0100) not equal to 16 be sure to read and understand Annex D.

If sent in an Encapsulated Format (i.e. other than the Native Format) the Value Representation OB is used. The Pixel Cells are encoded according to the encoding process defined by one of the negotiated Transfer Syntaxes (see Annex A). The encapsulated pixel stream of encoded pixel data is segmented in one or more Fragments which convey their explicit length. The sequence of Fragments of the encapsulated pixel stream is terminated by a delimiter, thus allowing the support of encoding processes where the resulting length of the entire pixel stream is not known until it is entirely encoded. This Encapsulated Format supports both Single-Frame and Multi-Frame images (as defined in PS 3.3).

8.2.1 JPEG IMAGE COMPRESSION

DICOM provides a mechanism for supporting the use of JPEG Image Compression through the Encapsulated Format (see PS 3.3). Annex A defines a number of Transfer Syntaxes which reference the JPEG Standard and provide a number of lossless (bit preserving) and lossy compression schemes.

Note: The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g. compression ratio) for JPEG lossy compression is also beyond the scope of this standard.

In order to facilitate interoperability of implementations conforming to the DICOM Standard which elect to use one or more of the Transfer Syntaxes for JPEG Image Compression, the following policy is specified:

- Any implementation which conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for lossless JPEG Image Compression, shall support the following lossless compression: The subset (first-order horizontal prediction [Selection Value 1) of JPEG Process 14 (DPCM, non-hierarchical with Huffman coding) (see Annex F).
- Any implementation which conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 8-bit lossy JPEG Image Compression, shall support the JPEG Baseline Compression (coding Process 1).
- Any implementation which conforms to the DICOM Standard and has elected to support any one of the Transfer Syntaxes for 12-bit lossy JPEG Image Compression, shall support the JPEG Compression Process 4.

Note: The DICOM conformance statement shall differentiate whether or not the implementation is capable of simply receiving or receiving and processing JPEG encoded images (see PS 3.2).

The use of the DICOM Encapsulated Format to support JPEG Compressed Pixel Data requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric Interpretation,

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Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG Interchange Format shall be used to decode the compressed data stream.

- Notes:
1. These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data stream was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.
 - When decompressing, should the characteristics explicitly specified in the compressed data stream (e.g. spatial subsampling or number of components or planar configuration) be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed data set might be encoded.
 2. Those characteristics not explicitly specified in the compressed data stream (e.g. color space which is not specified in the JPEG Interchange Format), or implied by the definition of the compression scheme (e.g. always unsigned in JPEG), can therefore be determined from the DICOM Data Element in the enclosing data set. For example a Photometric Interpretation of "YBR FULL 422" would describe the color space that is commonly used to lossy compress images using JPEG. It is unusual to use an RGB color space for lossy compression, since no advantage is taken of correlation between the red, green and blue components (e.g. of luminance), and poor compression is achieved.
 3. Should the compression process be incapable of encoding a particular form of pixel data representation (e.g. JPEG cannot encode signed integers, only unsigned integers), then ideally only the appropriate form should be "fed" into the compression process. However, for certain characteristics described in DICOM Data Elements but not explicitly described in the compressed data stream (such as Pixel Representation), then the DICOM Data Element should be considered to describe what has been compressed (e.g. the pixel data really is to be interpreted as signed if Pixel Representation so specifies).
 4. DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, JPEG lossy processes are limited to 12 bits, hence the value of Bits Stored should be 12 or less. Bits Allocated is irrelevant, and is likely to be constrained by the Information Object Definition in PS 3.3 to values of 8 or 16. Also, JPEG compressed data streams are always color-by-pixel and should be specified as such (a decoder can essentially ignore this element however as the value for JPEG compressed data is already known).

8.2.2 Run Length Encoding Compression

DICOM provides a mechanism for supporting the use of Run Length Encoding (RLE) Compression which is a byte oriented lossless compression scheme through the encapsulated Format (see PS 3.3 of this Standard). Annex G defines RLE Compression and its Transfer Syntax.

- Note: The RLE Compression algorithm described in Annex G is the compression used in the TIFF 6.0 specification known as the "PackBits" scheme.

The use of the DICOM Encapsulated Format to support RLE Compressed Pixel Data requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the compressed data.

- Notes:
1. These requirements were formerly specified in terms of the "uncompressed pixel data from which the compressed data was derived". However, since the form of the "original" uncompressed data stream could vary between different implementations, this requirement is now specified in terms of consistency with what is encapsulated.
 2. Those characteristics not implied by the definition of the compression scheme (e.g. always color-by-plane in RLE), can therefore be determined from the DICOM Data Element in the enclosing data set. For example a Photometric Interpretation of "YBR FULL" would describe the color space that is commonly used to losslessly compress images using RLE. It is unusual to use an RGB color space for RLE compression, since no advantage is taken of correlation between the red, green and blue components (e.g. of luminance), and poor compression is achieved (note however that the conversion from RGB to YBR FULL is itself lossy. A new photometric interpretation may be proposed in the future which allows lossless conversion from RGB and also results in better RLE compression ratios).

3. DICOM Data Elements should not describe characteristics that are beyond the capability of the compression scheme used. For example, RLE compressed data streams (using the algorithm mandated in the DICOM Standard) are always color-by-plane.

8.2.3 JPEG-LS IMAGE COMPRESSION

DICOM provides a mechanism for supporting the use of JPEG-LS Image Compression through the Encapsulated Format (see PS 3.3). Annex A defines a number of Transfer Syntaxes which reference the JPEG-LS Standard and provide a number of lossless (bit preserving) and lossy (near-lossless) compression schemes.

Note: The context where the usage of lossy (near-lossless) compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g. compression ratio) for JPEG-LS lossy (near-lossless) compression is also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support JPEG-LS Compressed Pixel Data requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG-LS Interchange Format shall be used to decode the compressed data stream.

Note: See also the notes in section 8.2.1.

8.2.4 JPEG 2000 IMAGE COMPRESSION

DICOM provides a mechanism for supporting the use of JPEG 2000 Image Compression through the Encapsulated Format (see PS 3.3). Annex A defines a number of Transfer Syntaxes which reference the JPEG 2000 Standard and provide lossless (bit preserving) and lossy compression schemes.

Note: The context where the usage of lossy compression of medical images is clinically acceptable is beyond the scope of the DICOM Standard. The policies associated with the selection of appropriate compression parameters (e.g. compression ratio) for JPEG 2000 lossy compression is also beyond the scope of this standard.

The use of the DICOM Encapsulated Format to support JPEG 2000 Compressed Pixel Data requires that the Data Elements which are related to the Pixel Data encoding (e.g. Photometric Interpretation, Samples per Pixel, Planar Configuration, Bits Allocated, Bits Stored, High Bit, Pixel Representation, Rows, Columns, etc.) shall contain values which are consistent with the characteristics of the compressed data stream. The Pixel Data characteristics included in the JPEG 2000 bit stream shall be used to decode the compressed data stream.

Note: These requirements are specified in terms of consistency with what is encapsulated, rather than in terms of the uncompressed pixel data from which the compressed data stream may have been derived.

When decompressing, should the characteristics explicitly specified in the compressed data stream be inconsistent with those specified in the DICOM Data Elements, those explicitly specified in the compressed data stream should be used to control the decompression. The DICOM data elements, if inconsistent, can be regarded as suggestions as to the form in which an uncompressed data set might be encoded.

The JPEG 2000 bit stream specifies whether or not a reversible or irreversible multi-component (color) transformation, if any, has been applied. If no multi-component transformation has been applied, then the components shall correspond to those specified by the DICOM Attribute Photometric Interpretation. If the JPEG 2000 reversible multi-component transformation has

been applied then the DICOM Attribute Photometric Interpretation shall be ~~YUV-RCTYBR~~ **RCT**. If the JPEG 2000 irreversible multi-component transformation has been applied then the DICOM Attribute Photometric Interpretation shall be YBR_ICT.

- Notes:**
1. For example, single component may be present, and the Photometric Interpretation may be MONOCHROME2.
 2. Though it would be unusual, would not take advantage of correlation between the red, green and blue components, and would not achieve effective compression, a Photometric Interpretation of RGB could be specified as long as no multi-component transformation was specified by the JPEG 2000 bit stream.
 3. Despite the application of a multi-component color transformation and its reflection in the Photometric Interpretation attribute, the “color space” remains undefined. There is currently no means of conveying “standard color spaces” either by fixed values (such as sRGB) or by ICC profiles. Note in particular that the JP2 file header is not sent in the JPEG 2000 bitstream that is encapsulated in DICOM.

The JPEG 2000 bitstream is capable of encoding both signed and unsigned pixel values, hence the value of Pixel Representation may be either 0 or 1 depending on what has been encoded (as specified in the SIZ marker segment in the precision and sign of component parameter).
[Editor’s note: what about when this varies by component ?]

The value of Planar Configuration is irrelevant since the manner of encoding components is specified in the JPEG 2000 standard, hence it shall be set to 0.

Add JPEG 2000 default requirements to Section 10:

Section 10 Transfer Syntax

A Transfer Syntax is a set of encoding rules able to unambiguously represent one or more Abstract Syntaxes. In particular, it allows communicating Application Entities to negotiate common encoding techniques they both support (e.g., byte ordering, compression, etc.). A Transfer Syntax is an attribute of a Presentation Context, one or more of which are negotiated at the establishment of an Association between DICOM Application Entities. This Association negotiation is specified in PS 3.8 and discussed in PS 3.7.

The selection of a Transfer Syntax applies to the encoding rules for the Data Set portion of a DICOM Message only. All DICOM Standard and Private Transfer Syntaxes implicitly specify a fixed encoding for the Command Set portion of a DICOM Message as Specified in PS 3.7.

This part of the DICOM Standard defines standard DICOM Transfer Syntaxes and assigns a unique Transfer Syntax Name to each one. The standard DICOM Transfer Syntaxes are specified in Annex A. The DICOM notation for Transfer Syntax names is the notation used for UIDs (see Section 9).

The organization responsible for the definition and registration of DICOM Transfer Syntaxes is NEMA. NEMA guarantees uniqueness for all DICOM Transfer Syntax Names.

Privately defined Transfer Syntax Names may also be used; however, they will not be registered by NEMA. Organizations that define private Transfer Syntax Names shall follow the registration process defined in Section 9.2.

10.1 DICOM DEFAULT TRANSFER SYNTAX

DICOM defines a default Transfer Syntax, the DICOM Implicit VR Little Endian Transfer Syntax (UID = "1.2.840.10008.1.2"), that shall be supported by every conformant DICOM Implementation. This implies that:

- a) If an Application Entity issues an A-ASSOCIATE request, it shall offer the DICOM Implicit VR Little Endian Transfer Syntax in at least one of the Presentation Contexts associated with each offered Abstract Syntax.

Note: Offering Abstract Syntax (AS1) in two Presentation Contexts with Transfer Syntaxes (TS1) and (TS2) is not valid, but offering AS1-TS1, AS1-TS2 and AS1-TSD is valid because the DICOM Default Little Endian Transfer Syntax (TSD) is present in at least one of the Presentation Contexts which are based on Abstract Syntax (AS1).

- b) If an Application Entity receives an A-ASSOCIATE indication corresponding to a request which follows the requirements specified in Section 10.1 a), every Presentation Context related to a given Abstract Syntax cannot be rejected in an A-ASSOCIATE response for the reason that none of the Transfer Syntaxes are supported.

Both of these requirements, a) and b), are waived when the Application Entity sending the pixel data has only access to the pixel data in lossy compressed form.

Note: In other words, every sending AE is required to be able to convert any dataset it is going to transmit into the Default Transfer Syntax, regardless of the form in which it originally received or stored the data set, except in the single case of when it received it in a lossy compressed form. In that exceptional case, the sending AE is permitted to propose only the lossy compressed Transfer Syntax appropriate to the lossy form that was received.

In particular, this waiver does not apply to data sets received in a lossless compressed form, which means that any AE receiving a data set in a lossless compressed Transfer Syntax that needs to re-send the data set is required to be able to decompress it in order to support (at least) the default Transfer Syntax.

10.2 TRANSFER SYNTAX FOR A DICOM DEFAULT OF LOSSLESS JPEG COMPRESSION

DICOM defines a default for lossless JPEG Image Compression, which uses a subset of coding Process 14 with a first-order prediction (Selection Value 1). It is identified by Transfer Syntax UID = "1.2.840.10008.1.2.4.70" and shall be supported by every DICOM implementation that chooses to support one or more of the lossless JPEG compression processes. This implies that:

- a) If an Application Entity issues an A-ASSOCIATE request where any offered Abstract Syntaxes is associated in one or more Presentation Context with a JPEG lossless compression Transfer Syntax, at least one of the Presentation Contexts which include this Abstract Syntax, shall include the DICOM Default Lossless JPEG Compression Transfer Syntax and the DICOM Default Transfer Syntax (uncompressed).

Note: Offering Abstract Syntax (AS1) in two Presentation Contexts with Transfer Syntaxes JPEG lossless (JL1) and (JL2) is not valid, but offering AS1-JL1, AS1-JL2, AS1-TSD, and AS1-JLD is valid because the DICOM Default JPEG Lossless Transfer Syntax (JLD) and the DICOM Default Transfer Syntax (TSD) are present in at least one of the Presentation Contexts which are based on Abstract Syntax (AS1).

- b) If an Application Entity that supports one or more lossless JPEG Transfer Syntax receives an A-ASSOCIATE indication corresponding to a request which follows the requirements specified in Section 10.2 a), every Presentation Context related to a given Abstract Syntax cannot be rejected in an A-ASSOCIATE response for the reason that the DICOM Default lossless JPEG Transfer Syntax is not supported.

10.3 TRANSFER SYNTAXES FOR A DICOM DEFAULTS OF LOSSY JPEG COMPRESSION

DICOM defines defaults for Lossy JPEG Image Compression, one for 8-bit images and the other for 12-bit images. JPEG coding Process 1 (identified by Transfer Syntax UID =

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688 "1.2.840.10008.1.2.4.50") is used for 8-bit images. JPEG coding Process 4 (identified by Transfer
689 Syntax UID = "1.2.840.10008.1.2.4.51") is used for 12-bit images. This implies that:

690 a) If an Application Entity issues an A-ASSOCIATE request where any offered Abstract
691 Syntaxes is associated in one or more Presentation Context(s) with a JPEG lossy
692 compression Transfer Syntax, at least one of the Presentation Contexts which include this
693 Abstract Syntax, shall include the appropriate DICOM Default Lossy JPEG Compression
694 Transfer Syntax.

695 Note: 1. Offering Abstract Syntax (AS1) in two Presentation Contexts with Transfer Syntaxes JPEG lossy
696 (JL1) and (JL2) is not valid, but offering AS1-JL1, AS1-JL2 and AS1-JLD is valid because the DICOM
697 Default JPEG Lossy Transfer Syntax (JLD) is present in at least one of the Presentation Contexts
698 which are based on Abstract Syntax (AS1).

699 2. The DICOM Default Transfer Syntax (uncompressed) may be offered if the sender has access to
700 the original pixel data in an uncompressed or lossless compressed form.

701 b) If an Application Entity that supports one or more Lossy JPEG Transfer Syntaxes receives
702 an A-ASSOCIATE indication corresponding to a request which follows the requirements
703 specified in Section 10.3 a), every Presentation Context related to a given Abstract Syntax
704 cannot be rejected in an A-ASSOCIATE response for the reason that the DICOM Default
705 lossy JPEG Transfer Syntax is not supported.

706 10.4 TRANSFER SYNTAX FOR DICOM RLE COMPRESSION

707 DICOM defines the RLE Compression (see Annex G). This implies that:

708 a) If an Application Entity issues an A-ASSOCIATE request where any offered Abstract
709 Syntaxes is associated in one or more Presentation Contexts(s) with RLE compression
710 Transfer Syntax, at least one of the Presentation Contexts which include this Abstract
711 Syntax, shall include the DICOM Default Transfer Syntax (uncompressed).

712

713 10.5 TRANSFER SYNTAX FOR A DICOM DEFAULT OF LOSSLESS AND LOSSY (NEAR- 714 LOSSLESS) JPEG-LS COMPRESSION

715 One Transfer Syntax is specified for JPEG-LS Lossless Image Compression, and one Transfer
716 Syntax is specified for JPEG-LS Lossy (Near-Lossless) Image Compression. The JPEG-LS Lossless
717 Transfer Syntax shall be supported as a baseline if the JPEG-LS Lossy (Near-Lossless) Transfer
718 Syntax is supported.

719 10.6 TRANSFER SYNTAX FOR A DICOM DEFAULT FOR JPEG 2000 COMPRESSION

720 One Transfer Syntax is specified for JPEG 2000 Lossless Image Compression, and one
721 Transfer Syntax is specified for JPEG 2000 Lossy Image Compression. ~~Any implementation~~
722 ~~that supports either transfer syntax shall also support the other.~~

723 Notes: 1. All JPEG 2000 codecs are required by ISO/IEC 15444-1 to support both reversible and
724 irreversible wavelet and multi-component transformations. The reason for specifying two
725 separate Transfer Syntaxes in DICOM is to allow an application to ~~require-request~~ the transfer
726 of images in a lossless manner when ~~necessary~~ possible.

727 2. No baseline using other compression schemes is required.

728 3. The waiver of the requirement in Section 10.1 to support the DICOM Default Transfer
729 Syntax still applies when the Application Entity sending the pixel data has only access to the
730 pixel data in lossy compressed form.

731

Add JPEG 2000 requirements to Annex A:

**Annex A
(Normative)
Transfer Syntax Specifications**

...

A.4 TRANSFER SYNTAXES FOR ENCAPSULATION OF ENCODED PIXEL DATA

These Transfer Syntaxes apply to the encoding of the entire DICOM Data Set, even though the image Pixel Data (7FE0,0010) portion of the DICOM Data Set is the only portion that is encoded by an encapsulated format. This implies that when a DICOM Message is being encoded according to an encapsulation Transfer Syntax the following requirements shall be met:

- a) The Data Elements contained in the Data Set structure shall be encoded with Explicit VR (with a VR Field) as specified in Section 7.1.2.
- b) The encoding of the overall Data Set structure (Data Element Tags, Value Length, etc.) shall be in Little Endian as specified in Section 7.3.
- c) The encoding of the Data Elements of the Data Set shall be as follows according to their Value Representations:
 - For all Value Representations defined in this part of the DICOM Standard, except for the Value Representations OB and OW, the encoding shall be in Little Endian as specified in Section 7.3.
 - For the Value Representations OB and OW, the encoding shall meet the following specification depending on the Data Element Tag:
 - Data Element (7FE0,0010) Pixel Data has the Value Representation OB and is a sequence of bytes resulting from one of the encoding processes. It contains the encoded pixel data stream fragmented into one or more Item(s). This Pixel Data Stream may represent a Single or Multi-frame Image. See Tables A.4-1 and A.4-2:
 - The Length of the Data Element (7FE0,0010) shall be set to the Value for Undefined Length (FFFFFFFH).
 - Each Data Stream Fragment encoded according to the specific encoding process shall be encapsulated as a DICOM Item with a specific Data Element Tag of Value (FFFE,E000). The Item Tag is followed by a 4 byte Item Length field encoding the explicit number of bytes of the Item.
 - All items containing an encoded fragment shall be made of an even number of bytes greater or equal to two. The last fragment of a frame may be padded, if necessary, to meet the sequence item format requirements of the DICOM Standard.

Notes:

1. Any necessary padding may be added in the JPEG or JPEG-LS compressed data stream as per ISO 10918-1 and ISO 14495-1 such that the End of Image (EOI) marker ends on an even byte boundary, or may be appended after the EOI marker, depending on the implementation.
2. ISO 10918-1 and ISO 14495-1 define the ability to add any number of padding bytes FFH before any marker (all of which also begin with FFH). It is strongly recommended that FFH padding bytes not be added before the Start of Image (SOI) marker.

- The first Item in the Sequence of Items before the encoded Pixel Data Stream shall be a Basic Offset Table item. The Basic Offset Table Item Value, however, is not required to be present:

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- 777 — When the Item Value is not present, the Item Length shall be zero (00000000H)
 778 (see Table A.4-1).
- 779 — When the Item Value is present, the Basic Offset Table Item Value shall contain
 780 concatenated 32-bit unsigned integer values that are byte offsets to the first
 781 byte of the Item Tag of the first fragment for each frame in the Sequence of
 782 Items. These offsets are measured from the first byte of the first Item Tag
 783 following the Basic Offset Table item (See Table A.4-2).
 784
- 785 Note: For a Multi-Frame Image containing only one frame or a Single Frame Image, the Basic Offset Table
 786 Item Value may be present or not. If present it will contain a single 00000000H value.
 787
- 788 — This Sequence of Items is terminated by a Sequence Delimiter Item with the
 789 Tag (FFFE,E0DD) and an Item Length Field of Value (00000000H) (i.e., no
 790 Value Field shall be present).
- 791 — Data Element (60xx,3000) Overlay Data
 792 — shall have the Value Representation OB or OW and shall be encoded in Little
 793 Endian.
- 794 — Data Element (50xx,3000) for Curve Data has the Value Representation specified in
 795 its Explicit VR Field. See the specification of the Curve Data Module in PS 3.3 for the
 796 enumerated list of allowable VRs. The component points shall be encoded in Little
 797 Endian.
- 798 — Data Element (5400,1010) Waveform Data has the Value Representation specified
 799 in its Explicit VR Field. The component points shall be encoded in Little Endian.
- 800 — Data Element (50xx,200C) Audio Sample Data has the Value Representation OB
 801 when Audio Sample Format (50xx,2002) specifies 8-bit values, and OW encoded in
 802 Little Endian when 16 bit values are specified. See the specification of the Audio
 803 Module in PS 3.3.
- 804 — Data Elements (0028,1201), (0028,1202), (0028,1203) Red, Green, Blue Palette
 805 Lookup Table Data have the Value Representation OW and shall be encoded in
 806 Little Endian.
- 807 Note: Previous versions of the Standard either did not specify the encoding of these Data
 808 Elements in this Part, but specified a VR of US or SS in PS 3.6 (1993), or specified OW
 809 in this Part but a VR of US, SS or OW in PS 3.6 (1996). The actual encoding of the
 810 values and their byte order would be identical in each case, though the explicitly
 811 encoded VR field would be different. However, an explicit VR of US or SS cannot be
 812 used to encode a table of 2^{16} elements, since the Value Length is restricted to 16 bits.
- 813 — Data Elements (0028,1101), (0028,1102), (0028,1103) Red, Green, Blue Palette
 814 Lookup Table Descriptor have the Value Representation SS or US (depending on
 815 rules specified in the IOD in PS 3.3), and shall be encoded in Little Endian. The first
 816 and third values are always interpreted as unsigned, regardless of the Value
 817 Representation.
- 818 — Data Elements (0028,1221), (0028,1222), (0028,1223) Segmented Red, Green,
 819 Blue Palette Color Lookup table Data have the Value Representation OW and shall
 820 be encoded in Little Endian.
- 821 — Data Element (0028,3006) Lookup Table Data has the Value Representation US, SS
 822 or OW and shall be encoded in Little Endian.
- 823 Note: Previous versions of the Standard did not specify the encoding of these Data Elements
 824 in this Part, but specified a VR of US or SS in PS 3.6 (1998). However, an explicit VR of
 825 US or SS cannot be used to encode a table of 2^{16} elements, since the Value Length is
 826 restricted to 16 bits. Hence a VR of OW has been added. The actual encoding of the
 827 values and their byte order would be identical in each case, though the explicitly
 828 encoded VR field would be different.
- 829 — Data Element (0028,3002) Lookup Table Descriptor has the Value Representation
 830 SS or US (depending on rules specified in the IOD in PS 3.3), and shall be encoded

831 in Little Endian. The first and third values are always interpreted as unsigned,
832 regardless of the Value Representation.
833

834 Note: For Data encoded with the Value Representation OB, the Data encoding is unaffected by Little
835 Endian or Big Endian byte ordering.

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Table A.4-1
EXAMPLE FOR ELEMENTS OF AN ENCODED SINGLE-FRAME IMAGE DEFINED AS A
SEQUENCE OF THREE FRAGMENTS WITHOUT BASIC OFFSET TABLE ITEM VALUE

Pixel Data Element Tag	Value Representation		Data Element Length	Data Element				
(7FE0, 0010) with VR of OB	OB	0000H Reserved	FFFF FFFFH undefined length	Basic Offset Table with NO Item Value		First Fragment (Single Frame) of Pixel Data		
				Item Tag (FFFE, E000)	Item Length 0000 0000H	Item Tag (FFFE, E000)	Item Length 0000 04C6H	Item Value Compressed Fragment
4 bytes	2 bytes	2 bytes	4 bytes	4 bytes	4 bytes	4 bytes	4 bytes	04C6H bytes

Data Element Continued							
Second Fragment (Single Frame) of Pixel Data			Third Fragment (Single Frame) of Pixel Data			Sequence Delimiter Item	
Item Tag (FFFE, E000)	Item Length 0000 024AH	Item Value Compressed Fragment	Item Tag (FFFE, E000)	Item Length 0000 0628H	Item Value Compressed Fragment	Sequence Delim. Tag (FFFE, E0DD)	Item Length 0000 000H
4 bytes	4 bytes	024AH bytes	4 bytes	4 bytes	0628H bytes	4 bytes	4 bytes

Table A.4-2
EXAMPLES OF ELEMENTS FOR AN ENCODED TWO-FRAME IMAGE DEFINED AS A SEQUENCE
OF THREE FRAGMENTS WITH BASIC TABLE ITEM VALUES

Pixel Data Element Tag	Value Representation		Data Element Length	Data Element					
(7FE0, 0010) with VR of OB	OB	0000H Reserved	FFFF FFFFH undefined length	Basic Offset Table with Item Value			First Fragment (Frame 1) of Pixel Data		
				Item Tag (FFFE, E000)	Item Length 0000 0008H	Item Value 0000 0000H 0000 0646H	Item Tag (FFFE, E000)	Item Length 0000 02C8H	Item Value Compressed Fragment
4 bytes	2 bytes	2 bytes	4 bytes	4 bytes	4 bytes	0008H bytes	4 bytes	4 bytes	02C8H bytes

Data Element Continued							
Second Fragment (Frame 1) of Pixel Data			Third Fragment (Frame 2) of Pixel Data			Sequence Delimiter Item	
Item Tag (FFFE, E000)	Item Length 0000 036EH	Item Value Compressed Fragment	Item Tag (FFFE, E000)	Item Length 0000 0BC8H	Item Value Compressed Fragment	Sequence Delimiter Tag (FFFE, E0DD)	Item Length 0000 0000H
4 bytes	4 bytes	036EH bytes	4 bytes	4 bytes	0BC8H bytes	4 bytes	4 bytes

A.4.1 JPEG IMAGE COMPRESSION

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO/IS-10918-1 (JPEG Part 1) and an International Draft Standard, ISO/IS-10918-2 (JPEG Part 2), known as the JPEG Standard, for digital compression and coding of continuous-tone still images. (See Annex F for further details.)

A DICOM Transfer Syntax for JPEG Image Compression shall be identified by a UID value, appropriate to its JPEG coding process, chosen from Table A.4-3.

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Table A.4-3
DICOM TRANSFER SYNTAX UIDS FOR JPEG

DICOM Transfer Syntax UID	JPEG coding process	JPEG description
1.2.840.10008.1.2.4.50	1	baseline
1.2.840.10008.1.2.4.51	2(8-bit),4(12-bit)	extended
1.2.840.10008.1.2.4.52	3(8-bit),5(12-bit)	extended
1.2.840.10008.1.2.4.53	6(8-bit),8(12-bit)	spectral selection, non-hierarchical
1.2.840.10008.1.2.4.54	7(8-bit),9(12-bit)	spectral selection, non-hierarchical
1.2.840.10008.1.2.4.55	10(8-bit),12(12-bit)	full progression, non-hierarchical
1.2.840.10008.1.2.4.56	11(8-bit),13(12-bit)	full progression, non-hierarchical
1.2.840.10008.1.2.4.57	14	lossless, non-hierarchical
1.2.840.10008.1.2.4.58	15	lossless, non-hierarchical
1.2.840.10008.1.2.4.59	16(8-bit),18(12-bit)	extended, hierarchical
1.2.840.10008.1.2.4.60	17(8-bit),19(12-bit)	extended, hierarchical
1.2.840.10008.1.2.4.61	20(8-bit),22(12-bit)	spectral selection, hierarchical
1.2.840.10008.1.2.4.62	21(8-bit),23(12-bit)	spectral selection, hierarchical
1.2.840.10008.1.2.4.63	24(8-bit),26(12-bit)	full progression, hierarchical
1.2.840.10008.1.2.4.64	25(8-bit),27(12-bit)	full progression, hierarchical
1.2.840.10008.1.2.4.65	28	lossless, hierarchical
1.2.840.10008.1.2.4.66	29	lossless, hierarchical
1.2.840.10008.1.2.4.70	14 (Selection Value 1)	lossless, non-hierarchical, first-order prediction

Note: DICOM identifies, to increase the likelihood of successful association, three Transfer Syntaxes for Default JPEG Compression Image processes (see Sections 8.2.1 and 10).

If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each fragment shall contain encoded data from a single-frame image.

For all images, including all frames of a multi-frame image, the JPEG Interchange Format shall be used (the table specification shall be included).

If images with Photometric Interpretation (0028,0004) YBR_FULL_422 or YBR_PARTIAL_422, are encoded with JPEG coding Process 1 (non hierarchical with Huffman coding), identified by DICOM Transfer Syntax UID 1.2.840.10008.1.2.4.50 the minimum compressible unit is $YYC_B C_R$, where Y, C_B , and C_R are 8 by 8 blocks of pixel values. The data stream encodes two Y blocks followed by the corresponding C_B and C_R blocks.

A.4.2 RLE COMPRESSION

Annex G defines a RLE Compression Transfer Syntax. This transfer Syntax is identified by the UID value 1.2.840.10008.1.2.5. If the object allows multi-frame images in the pixel data field, then each frame shall be encoded separately. Each frame shall be encoded in one and only one Fragment (see PS 3.5.8.2).

A.4.3 JPEG-LS IMAGE COMPRESSION

The International Standards Organization ISO/IEC JTC1 has developed an International Standard, ISO/IS-14495-1 (JPEG-LS Part 1), for digital compression and coding of continuous-tone still images. (See Annex F for further details.)

876 A DICOM Transfer Syntax for JPEG-LS Image Compression shall be identified by a UID value,
877 appropriate to its JPEG-LS coding process.

878 Two Transfer Syntaxes are specified for JPEG-LS:

- 879 1. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.80, which specifies the use of the
880 lossless mode of JPEG-LS. In this mode the absolute error between the source and
881 reconstructed images will be zero.
- 882 2. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.81, which specifies the use of the
883 near-lossless mode of JPEG-LS. In this mode, the absolute error between the source and
884 reconstructed images will be constrained to a finite value that is conveyed in the
885 compressed bit stream. Note that this process can, at the discretion of the encoder, be
886 used to compress images with an error constrained to a value of zero, resulting in no loss
887 of information.

888 If the object allows multi-frame images in the pixel data field, then each frame shall be encoded
889 separately. Each fragment shall contain encoded data from a single-frame image.

890 For all images, including all frames of a multi-frame image, the JPEG-LS Interchange Format shall
891 be used (all parameter specifications shall be included).

892 A.4.4 JPEG 2000 IMAGE COMPRESSION

893 The International Standards Organization ISO/IEC JTC1 has developed an International
894 Standard, ISO/IS 15444-1 (JPEG 2000 Part 1), for digital compression and coding of continuous-
895 tone still images. (See Annex F for further details.)

896 A DICOM Transfer Syntax for JPEG 2000 Image Compression shall be identified by a UID value,
897 appropriate to ~~its~~ the choice of JPEG-LS 2000 coding process.

898 Two Transfer Syntaxes are specified for JPEG 2000:

- 899 1. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.90, which specifies the use of the
900 lossless (reversible) mode of JPEG 2000 Part 1 (ISO/IS 15444-1) (i.e. the use of a
901 reversible wavelet transformation and a reversible color component transformation,
902 if applicable, and no quantization).
- 903 2. A Transfer Syntax with a UID of 1.2.840.10008.1.2.4.91, which specifies the use of the
904 lossy (irreversible) mode of JPEG 2000 Part 1 (ISO/IS 15444-1) (i.e. the use of an
905 irreversible wavelet transformation and an irreversible color component
906 transformation, if applicable, and optionally quantization).

907 Note: When using the lossy (irreversible) mode, even if no quantization is performed, some
908 loss will always occur due to the finite precision of the calculation of the wavelet and
909 multi-component transformations.

911 Only the features defined in JPEG 2000 Part 1 (ISO/IEC 15444-1) are permitted for these two
912 Transfer Syntaxes. Additional features and extensions that may be defined in other parts of
913 JPEG 2000 shall not be included in the compressed bitstream unless they can be decoded or
914 ignored without loss of fidelity by all Part 1 compliant implementations.

915 If the object allows multi-frame images in the pixel data field, then each frame shall be encoded
916 separately. Each fragment shall contain encoded data from a single-frame image.

917 Note: That is, the processes defined in ISO/IEC 15444-1 shall be applied on a per-frame basis. The
918 proposal for encapsulation of multiple frames in a non-DICOM manner in so-called "Motion-
919 JPEG" or "M-JPEG" defined in 15444-3 are not used.

920

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For all images, including all frames of a multi-frame image, the JPEG 2000 bitstream specified in ISO/IEC 15444-1 shall be used. The optional JP2 file format header shall NOT be included.

Note: The role of the JP2 file format header is fulfilled by the non-pixel data attributes in the DICOM data set.

Add JPEG 2000 requirements to Annex F:

Annex F (Informative) Encapsulated images as part of a DICOM message

The following remarks apply generally to communicating an encoded image within a message structure according to the DICOM Standard:

- a) In the course of including an encoded image in a DICOM message, the encoding is not changed. The encoded data stream is merely segmented and encapsulated according to the protocols of the DICOM Standard. After unpacking the DICOM message, the encoded data stream can be fully reconstructed at the receiving node.
- b) The object definition of the DICOM Standard is always determining format and other choices that a specific encoding implementation may offer. The encoded image must be consistent with the definition of the object of which the encoded image is part. For example:
 - 1) If the object is defined to contain 10-bit pixel data, it is assumed that the encoding process is one that accepts at least 10-bit data. Hence, there is no need for defining separate Transfer Syntaxes, e.g. for 8-bit or 12-bit implementations. Any 12-bit implementation is assumed to operate in an 8-bit process if the object is defined to contain 8-bit data.
 - 2) If the image of an object is interleaved, the encoding process must reproduce the interleaving.
- c) Specifications in the encoding file header must be consistent with the DICOM Message header, e.g. regarding the number of rows and columns.
- d) The byte order specification of an encoded file is not altered in the course of encapsulating it in a DICOM message.

F.1 ENCAPSULATED JPEG ENCODED IMAGES

The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an International Standard, ISO/IS-10918-1 (JPEG Part 1) and International Draft Standard ISO/IS-10918-2 (JPEG Part 2), for the digital compression and coding of continuous-tone still images. This standard is collectively known as the JPEG Standard.

Part 1 of the JPEG Standard sets out requirements and implementation guidelines for the coded representation of compressed image data to be interchanged between applications. The processes and representations are intended to be generic in order to support the broad range of applications for color and grayscale still images for the purpose of communications and storage within computer systems. Part 2 of the JPEG Standard defines tests for determining whether implementations

964 comply with the requirements of the various encoding and decoding processes specified in Part 1 of
 965 the JPEG Standard.

966 The JPEG Standard specifies lossy and lossless code processes. The lossy coding is based on the
 967 discrete cosine transform (DCT), permitting data compression with an adjustable compression ratio.
 968 The lossless coding employs differential pulse code modulation (DPCM).

969 The JPEG Standard permits a variety of coding processes for the coder and decoder. These
 970 processes differ in coding schemes for the quantified data and in sample precision. The coding
 971 processes are consecutively numbered as defined in the International Draft Standard ISO/IS-10918-
 972 2 (JPEG Part 2), and are summarized in Table F.1-1. The simplest DCT-based coding process is
 973 referred to as Baseline Sequential with Huffman Coding for 8-bit Samples.

974 **Table F.1-1**
 975 **JPEG MODES OF IMAGE CODING**

No.	Description	Lossy LY Lossless LL	Non- Hierarchical NH Hierarchical H	Sequential S Progressive P	Transform	Coding	Accepted Bits
1	Baseline	LY	NH	S	DCT	Huffman	8
2	Extended	LY	NH	S	DCT	Huffman	8
3	Extended	LY	NH	S	DCT	Arithmetic	8
4	Extended	LY	NH	S	DCT	Huffman	12
5	Extended	LY	NH	S	DCT	Arithmetic	12
6	Spectral selection only	LY	NH	P	DCT	Huffman	8
7	Spectral selection only	LY	NH	P	DCT	Arithmetic	8
8	Spectral selection only	LY	NH	P	DCT	Arithmetic	12
9	Spectral selection only	LY	NH	P	DCT	Huffman	12
10	Spectral selection only	LY	NH	P	DCT	Arithmetic	8
11	Spectral selection only	LY	NH	P	DCT	Huffman	8
12	Spectral selection only	LY	NH	P	DCT	Arithmetic	12
13	Full progression	LY	NH	P	DCT	Arithmetic	12
	Full progression					Huffman	
	Full progression					Arithmetic	
	Full progression					Arithmetic	
14	Lossless	LL	NH	S	DPCM	Huffman	2-16
15	Lossless	LL	NH	S	DPCM	Arithmetic	2-16
16	Extended sequential	LY	H	S	DCT	Huffman	8
17	Extended sequential	LY	H	S	DCT	Arithmetic	8
18	Extended sequential	LY	H	S	DCT	Arithmetic	12
19	Extended sequential	LY	H	S	DCT	Huffman	12
						Arithmetic	
20	Spectral selection only	LY	H	P	DCT	Huffman	8
21	Spectral selection only	LY	H	P	DCT	Arithmetic	8
22	Spectral selection only	LY	H	P	DCT	Arithmetic	12
23	Spectral selection only	LY	H	P	DCT	Huffman	12
24	Spectral selection only	LY	H	P	DCT	Arithmetic	8

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25	Spectral selection only	LY	H	P	DCT	Huffman	8
26	Full progression	LY	H	P	DCT	Arithmetic	12
27	Full progression	LY	H	P	DCT	Huffman	12
	Full progression					Arithmetic	
	Full progression						
28	Lossless	LL	H	S	DPCM	Huffman	2-16
29	Lossless	LL	H	S	DPCM	Arithmetic	2-16

976

977 The different coding processes specified in the JPEG Standard are closely related. By extending the
 978 capability of an implementation, increasingly more 'lower level' processes can also be executed by
 979 the implementation. This is shown in Tables F.1-2 and F.1-3 for Huffman and Arithmetic Coding,
 980 respectively. Table F.1-4 presents the capabilities for lossless implementations.

981 ~~It is worth recognizing that implementations using arithmetic coding have the capability of~~
 982 ~~performing Huffman coded operations with two Huffman tables since they must be able to~~
 983 ~~execute the baseline process. Hence, by increasing the capability of operating with two~~
 984 ~~additional Huffman tables, the odd-numbered coding processes with arithmetic coding (Table~~
 985 ~~F.1-1) can also execute all corresponding even-numbered processes with Huffman coding~~
 986 ~~(Table F.1-5).~~

987 Inclusion of a JPEG-coded image in a DICOM message is facilitated by the use of specific Transfer
 988 Syntaxes which are defined in Annex A. Independent of the JPEG coding processes, the same
 989 syntax applies. The only distinction for different processes in the syntax is the UID value. Table F.1-5
 990 lists the UID values in the Transfer Syntax for the various JPEG coding processes for reference.

991 **Table F.1-2**
 992 **RELATIONSHIP BETWEEN THE LOSSY JPEG HUFFMAN CODING PROCESSES**

993 * Coding process of column can execute coding process of row

Process	1	2	4	6	8	10	12	16	18	20	22	24	26
1	*	*	*	*	*	*	*	*	*	*	*	*	*
2		*	*	*	*	*	*	*	*	*	*	*	*
4			*		*		*		*		*		*
6				*	*	*	*		*	*	*	*	*
8					*		*				*		*
10						*	*					*	*
12							*						*
16								*	*	*	*	*	*
18									*		*		*
20										*	*	*	*
22											*		*
24												*	*
26													*

994

Table F.1-3
RELATIONSHIP BETWEEN THE LOSSY JPEG ARITHMETIC CODING PROCESSES
~~* Coding process of column can execute coding process of row~~

Process	1	3	5	7	9	11	13	17	19	21	23	25	27
1*	*	*	*	*	*	*	*	*	*	*	*	*	*
3		*	*	*	*	*	*	*	*	*	*	*	*
5			*		*		*		*		*		*
7				*	*	*	*			*	*	*	*
9					*		*				*		*
11						*	*					*	*
13							*						*
17								*	*	*	*	*	*
19									*		*		*
21										*	*	*	*
23											*		*
25												*	*
27													*

+ The Baseline Coding Process, which uses Huffman encoding, is required by all lossy coding processes.

Table F.1-4
RELATIONSHIP BETWEEN THE LOSSLESS JPEG PROCESSES
~~* Coding process of column can execute coding process of row~~

Process	44	45	28	29
44	*		*	
45		*		*
28			*	
29				*

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Table F.1-5
IDENTIFICATION OF JPEG CODING PROCESSES IN DICOM

DICOM Transfer Syntax UID	JPEG process	JPEG description	capable of performing	
				lossy arithmetic coding w/opt. 4 Huffman tables
1.2.840.10008.1.2.4.50	1	baseline	1	
1.2.840.10008.1.2.4.51	2,4	extended	1,2,4	
1.2.840.10008.1.2.4.52	3,5	extended	1,3,5	ALL ≤ 5
1.2.840.10008.1.2.4.53	6,8	spect. select. NH	1,2,4,6,8	
1.2.840.10008.1.2.4.54	7,9	spect. select. NH	1,3,5,7,9	ALL ≤ 9
1.2.840.10008.1.2.4.55	10,12	full progression NH	1,2,4,6,8,10,12	
1.2.840.10008.1.2.4.56	11,13	full progression NH	1,3,5,7,9,11,13	ALL ≤ 13
1.2.840.10008.1.2.4.57	14	lossless NH	14	
1.2.840.10008.1.2.4.58	15	lossless NH	15	
1.2.840.10008.1.2.4.59	16,18	extended H	1,2,4,16,18	
1.2.840.10008.1.2.4.60	17,19	extended H	1,3,5,17,19	1,2,3,4,5,16,17,18,19
1.2.840.10008.1.2.4.61	20,22	spect. select. H	1,2,4,6,8,16,18,20,22	
1.2.840.10008.1.2.4.62	21,23	spect. select. H	1,3,5,7,9,17,19,21,23	1,2,3,4,5,6,7,8,9,16,17,18,19,20,21,22,23
1.2.840.10008.1.2.4.63	24,26	full progression H	1,2,4,6,8,10,12,16,18, 20,22,24,26	
1.2.840.10008.1.2.4.64	25,27	full progression H	1,3,5,7,9,11,13,17,19, 21,23,25,27	ALL ≤ 27, EXCEPT 14,15
1.2.840.10008.1.2.4.65	28	lossless H	14,28	
1.2.840.10008.1.2.4.66	29	lossless H	15,29	
1.2.840.10008.1.2.4.70	14 Selectio n Value 1	lossless NH, first-order prediction		

F.2 ENCAPSULATED JPEG-LS ENCODED IMAGES

The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an International Standard, ISO/IS-14495-1 (JPEG-LS Part 1), for the digital compression and coding of continuous-tone still images. This standard is known as the JPEG-LS Standard.

Part 1 of the JPEG-LS Standard sets out requirements and implementation guidelines for the coded representation of compressed image data to be interchanged between applications. The processes and representations are intended to be generic in order to support the broad range of applications for color and grayscale still images for the purpose of communications and storage within computer systems.

The JPEG-LS Standard specifies a single lossy (near-lossless) code process that can achieve lossless compression by constraining the absolute error value during encoding to zero. The lossless and lossy (near-lossless) coding is based on a predictive scheme with statistical modeling, in which differences between pixels and their surround are computed and their context modeled prior to

1020 coding, with a run-length escape mechanism. This scheme achieves consistently better compression
1021 in lossless mode than the lossless processes of JPEG defined in ISO 10918-1, with less complexity.

1022 Though a different coding process from those specified in ISO 10918-1 is used, the syntax of the
1023 encoded bit stream is closely related.

1024 A single JPEG-LS process is used for bit depths up to 16 bits.

1025 Inclusion of a JPEG-LS coded image in a DICOM message is facilitated by the use of specific
1026 Transfer Syntaxes that are defined in Annex A.

1027 **F.3 ENCAPSULATED JPEG 2000 ENCODED IMAGES**

1028 The International Standards Organization (ISO/IEC JTC1/SC2/WG10) has prepared an
1029 International Standard, ISO/IS-15444-1 (JPEG 2000 Part 1), for the digital compression and
1030 coding of continuous-tone still images. This standard is known as the JPEG 2000 Standard.

1031 Part 1 of the JPEG 2000 Standard sets out requirements and implementation guidelines for the
1032 coded representation of compressed image data to be interchanged between applications. The
1033 processes and representations are intended to be generic in order to support the broad range
1034 of applications for color and grayscale still images for the purpose of communications and
1035 storage within computer systems.

1036 The JPEG 2000 Standard specifies

1037 Though a different coding process from those specified in ISO 10918-1 is used, the syntax of
1038 the encoded bit stream is closely related.

1039 A single JPEG 2000 process is used for bit depths up to 16 bits.

1040 Inclusion of a JPEG 2000 coded image in a DICOM message is facilitated by the use of specific
1041 Transfer Syntaxes that are defined in Annex A.

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Changes to

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NEMA Standards Publication PS 3.6-2000

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Digital Imaging and Communications in Medicine (DICOM)

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Part 6: Data Dictionary

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Add new UIDs to Annex xx:

**Annex A Registry of DICOM unique identifiers (UID)
(Normative)**

Table A-1 lists the UID values which are registered and used throughout the Parts of the DICOM Standard. This central registry ensures that when additional UIDs are assigned, non duplicate values are assigned.

**Table A-1
UID VALUES**

UID Value	UID NAME	UID TYPE	Part
1.2.840.10008.1.1	Verification SOP Class	SOP Class	PS 3.4
1.2.840.10008.1.2	Implicit VR Little Endian: Default Transfer Syntax for DICOM	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.1	Explicit VR Little Endian	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.2	Explicit VR Big Endian	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.50	JPEG Baseline (Process 1): Default Transfer Syntax for Lossy JPEG 8 Bit Image Compression	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.51	JPEG Extended (Process 2 & 4): Default Transfer Syntax for Lossy JPEG 12 Bit Image Compression (Process 4 only)	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.52	<i>JPEG Extended (Process 3 & 5) (Retired)</i>	<i>Transfer Syntax</i>	<i>PS 3.5</i>
1.2.840.10008.1.2.4.53	<i>JPEG Spectral Selection, Non-Hierarchical (Process 6 & 8) (Retired)</i>	<i>Transfer Syntax</i>	<i>PS 3.5</i>
1.2.840.10008.1.2.4.54	<i>JPEG Spectral Selection, Non-Hierarchical (Process 7 & 9) (Retired)</i>	<i>Transfer Syntax</i>	<i>PS 3.5</i>
1.2.840.10008.1.2.4.55	<i>JPEG Full Progression, Non-Hierarchical (Process 10 & 12) (Retired)</i>	<i>Transfer Syntax</i>	<i>PS 3.5</i>
1.2.840.10008.1.2.4.56	<i>JPEG Full Progression, Non-Hierarchical (Process 11 & 13) (Retired)</i>	<i>Transfer Syntax</i>	<i>PS 3.5</i>

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1.2.840.10008.1.2.4.57	JPEG Lossless, Non-Hierarchical (Process 14)	Transfer Syntax	PS 3.5
<u>1.2.840.10008.1.2.4.58</u>	<u>JPEG Lossless, Non-Hierarchical (Process 15) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.59</u>	<u>JPEG Extended, Hierarchical (Process 16 & 18) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.60</u>	<u>JPEG Extended, Hierarchical (Process 17 & 19) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.61</u>	<u>JPEG Spectral Selection, Hierarchical (Process 20 & 22) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.62</u>	<u>JPEG Spectral Selection, Hierarchical (Process 21 & 23) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.63</u>	<u>JPEG Full Progression, Hierarchical (Process 24 & 26) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.64</u>	<u>JPEG Full Progression, Hierarchical (Process 25 & 27) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.65</u>	<u>JPEG Lossless, Hierarchical (Process 28) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.66</u>	<u>JPEG Lossless, Hierarchical (Process 29) (Retired)</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
1.2.840.10008.1.2.4.70	JPEG Lossless, Non-Hierarchical, First-Order Prediction (Process 14 [Selection Value 1]): Default Transfer Syntax for Lossless JPEG Image Compression	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.80	JPEG-LS Lossless Image Compression	Transfer Syntax	PS 3.5
1.2.840.10008.1.2.4.81	JPEG-LS Lossy (Near-Lossless) Image Compression	Transfer Syntax	PS 3.5
<u>1.2.840.10008.1.2.4.90</u>	<u>JPEG-LS 2000 Lossless Image Compression</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
<u>1.2.840.10008.1.2.4.91</u>	<u>JPEG-LS 2000 Lossy Image Compression</u>	<u>Transfer Syntax</u>	<u>PS 3.5</u>
1.2.840.10008.1.2.5	RLE Lossless	Transfer Syntax	PS 3.5
1.2.840.10008.1.3.10	Media Storage Directory Storage	SOP Class	PS 3.4

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Changes to

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NEMA Standards Publication PS 3.11-2000

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Digital Imaging and Communications in Medicine (DICOM)

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Part 11: Media Application Profiles

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1081 *Add any new profiles that use the JPEG 2000 transfer syntaxes here:*

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